

New species of mite harvestmen from the Wet Tropics of Queensland, Australia, with commentary on biogeography of the genus *Austropurcellia* (Opiliones: Cyphophthalmi: Pettalidae)

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Abstract. Cyphophthalmi, commonly known as mite harvestmen, are a suborder of cryptic Opiliones with a global distribution. The genus *Austropurcellia* Juberthie 1988 is a lineage of mite harvestmen currently known from a small number of localities in the forests of Queensland, Australia. We describe four new species of *Austropurcellia* (*A. alata*, *A. culuinis*, *A. despectata*, and *A. vicina*) from museum lots; each new species is known from only a single collection and few specimens. We present the first key to the species of *Austropurcellia*, a catalogue of known collecting localities, and a distribution map. Although our current knowledge of the diversity and distribution of this genus is certainly incomplete, it is clear that these narrow-range endemics have great potential as a system for understanding the role of historical forest fragmentation in the evolution of rainforest animals.

Keywords: Biodiversity, dispersal, endemism, evolution

Australia's Wet Tropics World Heritage Area comprises 8,940 km² of tropical rainforests stretching from Townsville to Cooktown along Queensland's coast (Fig. 1), with the majority of land protected in national parks or other reserves. Although the area represents only 0.1% of the land area of Australia, it is home to a huge diversity of the continent's animal life, including a third of all Australian mammals and at least 75 regionally endemic vertebrates (Nix 1991). Over the past decade, interest in the fauna of the Wet Tropics has increased as the area has emerged as a model system for understanding patterns and processes of rainforest animal diversification (e.g., Joseph et al. 1995; Hugall et al. 2002; Hugall et al. 2003; Bell et al. 2004; Bell et al. 2007; Moussalli et al. 2009).

Cyphophthalmi, the arachnids commonly known as mite harvestmen, are a globally distributed suborder of Opiliones (harvestmen or daddy long-legs) that currently includes 185 described species and subspecies, including the four new species described here (Giribet 2011). They are small (2–5 mm long), morphologically conserved animals that spend their entire life cycle in leaf litter habitats, with the exception of one cave-dwelling species (Juberthie 1970). Mite harvestmen are short-range endemics (sensu Harvey 2002), with most species only known from a handful of localities within a 100-km radius, even in areas that have been sampled on a very fine geographic scale (e.g., Boyer & Giribet 2009). In addition, no Cyphophthalmi are known from any Darwinian islands (sensu Gillespie and Roderick 2002), such as islands formed de novo by volcanoes in the mid-ocean, suggesting that these invertebrates are unable to disperse across oceanic barriers (Giribet 2000) (but see Clouse and Giribet (2007) for a possible exception). Despite their limited vagility, these animals are found in leaf litter habitats worldwide. This paradox is explained by the great age of the Cyphophthalmi lineage. Their sister group is known from the Devonian (Dunlop et al. 2003), and recent molecular analyses have dated the origin of the suborder at 345 Ma (Giribet et al. 2009). These animals also have excellent persistence; specifically, they require only very small patches of suitable habitat and therefore can withstand severe habitat contraction. For

example, one of the authors (SLB) has collected these animals in New Zealand from a patch of forest habitat measuring only 10 m at its widest and surrounded on all sides by pasture grazed by cattle. Because these animals display species-level endemism on a fine geographic scale, their biodiversity is likely poorly known in most areas, with exceptions in places such as New Zealand where they have been studied with dense geographic sampling (e.g., Boyer & Giribet 2003; Boyer et al. 2007; Boyer & Giribet 2009).

The cyphophthalmid family Pettalidae has a classical Temperate Gondwanan distribution, with representatives in Chile, South Africa, Madagascar, Sri Lanka, New Zealand and Australia. Pettalidae is a monophyletic group, with estimated ages of nodes within the phylogeny consistent with the hypothesis that the distribution of the family predates the breakup of the former supercontinent (Boyer & Giribet 2007; Boyer et al. 2007; Giribet et al. 2009). Members of the pettalid genus *Austropurcellia* are known from a handful of localities scattered throughout the Wet Tropics, but previous authors have suggested that the diversity of the Queensland lineage is poorly known (Juberthie 1988; Giribet 2003).

We performed a survey of collections of mite harvestmen from Queensland, including collections from the Queensland Museum, the Australian National Insect Collection, the Western Australian Museum, and the Muséum d'Histoire Naturelle, Geneva. As a result, we have identified four new morphologically distinct species of *Austropurcellia* from the Wet Tropics, bringing the total number of known species to ten and confirming expectations that there is significant undescribed diversity within this genus. Here, we describe these new species and discuss the biogeography of *Austropurcellia*.

METHODS

Localities were mapped with ArcInfo 10 (ESRI, Incorporated) using recorded collection coordinates when available, or by estimation when coordinates were not available.

For each new species, we examined one male specimen with a JEOL JSM-6610LV Scanning Electron Microscope (SEM). Total body length refers to the distance between the anterior median and posterior median margins of the dorsal scutum.

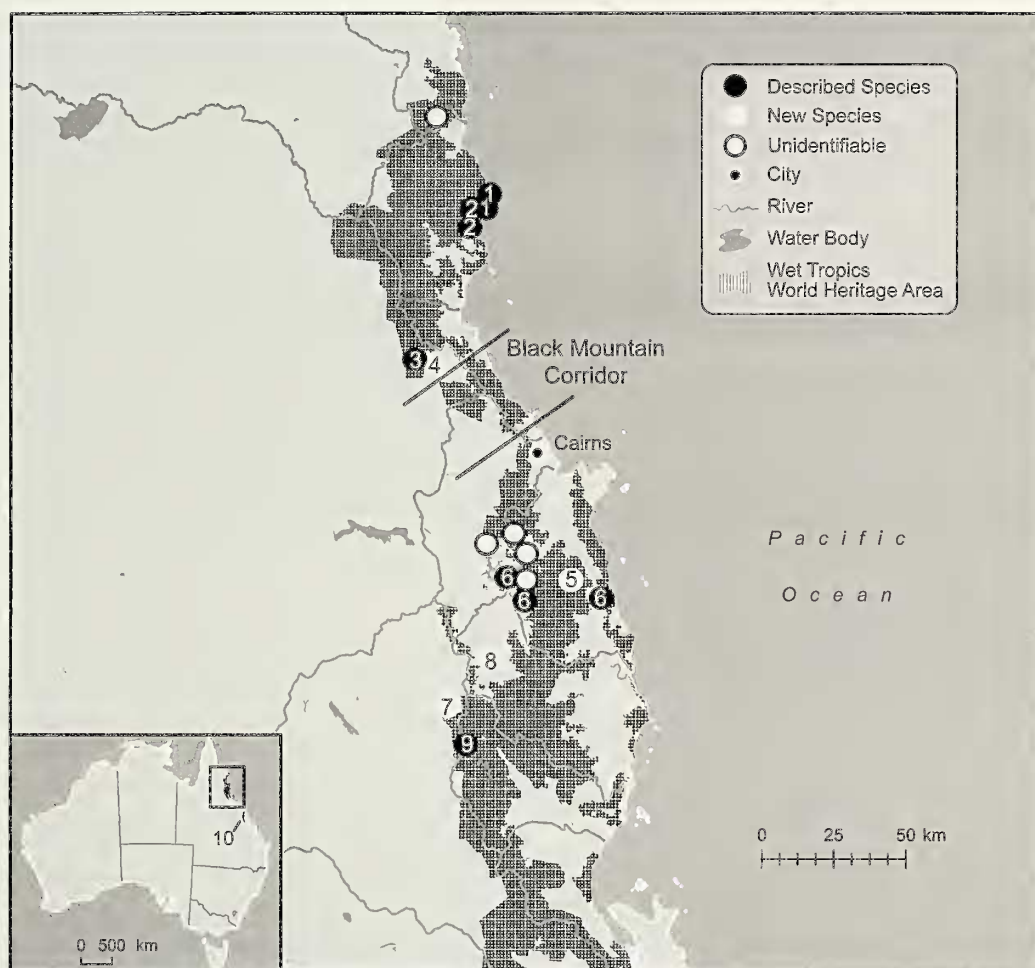


Figure 1.—Distribution of the genus *Austropurcellia*. Black points indicate previously described species; white points indicate new species. 1. *A. forsteri*. 2. *A. arcticosa*. 3. *A. scoparia*. 4. *A. vicina* n. sp. 5. *A. culminis* n. sp. 6. *A. daviesae*. 7. *A. alata* n. sp. 8. *A. despectata* n. sp. 9. *A. woodwardi*. 10. *A. capricornia*.

Lengths of leg and palp articles were measured on their dorsal side, from anterior to posterior margin, along the mid-line; widths (depths) on the lateral side, at the widest point, except for tarsus IV of the male, which was measured at the distal point of insertion of the adenostyle. Tarsal length does not include the claw. All appendage measurements refer to the paratype specimens studied with SEM with the exception of *Austropurcellia alata*, for which the mounted specimen is designated the holotype. We took light microscope images of holotype animals using an Olympus SZX10 microscope.

The specimens utilized in this study are lodged in the following institutions: Australian National Insect Collection, CSIRO, Canberra, Australia (ANIC); Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, USA (MCZ); Muséum d'Histoire Naturelle, Geneva, Switzerland (MHNG); Muséum National d'Histoire Naturelle, Paris, France (MNHN); and Queensland Museum, Brisbane, Australia (QM).

RESULTS AND DISCUSSION

Diversity and taxonomy of *Austropurcellia*.—In his 1988 description of the genus *Austropurcellia*, C. Juberthie states that he received a number of cyphophthalmid specimens from Valerie Todd Davies, then Curator of Arachnids at the Queensland Museum that (in addition to *A. scoparia*) included

eight new species from the genus *Neopurcellia* and two new species of *Rakaia*. Juberthie (1998, 2000) described two more of these, *Rakaia daviesae* Juberthie 1988 and *Neopurcellia forsteri* Juberthie 2000, both of which have subsequently been transferred to *Austropurcellia* (Boyer and Giribet 2007). Although the specimens representing the remaining undescribed species cannot be located at the present time (G. Giribet personal communication), Juberthie's remark indicates that the diversity of Cyphophthalmi from Queensland was not well described in 1988. The present study, based on specimens from museum lots borrowed from ANIC, QM and MHNG, adds four more species, but mapping of known localities strongly suggests that *Austropurcellia*'s diversity remains poorly sampled.

Morphological diversity of *Austropurcellia* is found in the male anal plate and associated scopulae, male tarsus IV (which varies both in the degree of bisegmentation and the shape of the adenostyle) and the degree of ornamentation of tarsi and metatarsi of legs I and II. In recent years, our understanding of the characters that distinguish major lineages within the family Pettalidae has been altered by molecular phylogenetic studies. For example, the character once used to distinguish *Neopurcellia* from *Rakaia*, bisegmentation of tarsus IV of the male, is more rapidly evolving than previously suspected. Molecular phylogenies have demonstrated that tarsus IV has

switched between bisegmented, entire, and partially bisegmented several times over the course of the evolution of the family Pettalidae (Boyer & Giribet 2007, 2009). The discovery of *Austropurcellia culminis*, which differs from *A. daviesae* only in degree of bisegmentation of tarsus IV, confirms that this character is rapidly evolving. *Austropurcellia culminis* and *A. daviesae* (Juberthie 1989) both occur around Bellenden Ker, which taken together with their extremely similar morphology suggests that these taxa are sister species. The minimal locality data currently available suggests that these species may occur at different elevations; while *A. daviesae* is known from several localities, *A. culminis* has only been collected at the summit of Bellenden Ker itself. Genetic data collected from many individuals from several localities, as well as precisely georeferenced locality data, would help to clarify the evolutionary relationships of these two very similar (but morphologically distinct) species.

Another character that was formerly considered to be of taxonomic importance at the level of genus is the extent of ornamentation of the first and second metatarsi. Juberthie (1988) originally diagnosed the genus *Austropurcellia* as distinguished from *Rakaia* by the presence of a bisegmented fourth tarsus of the male, and from *Neopurcellia* by the degree of ornamentation of the second metatarsus (fully ornamented in *Austropurcellia*, ornamented only in the basal half in *Neopurcellia*). Our work confirms that the degree and type of ornamentation found on metatarsus II varies within *Austropurcellia*; however, rather than characterizing metatarsus II as fully ornamented in some and partially ornamented in others, we distinguish between uniformly ornamented versus non-uniformly ornamented. In some specimens with a non-uniformly ornamented metatarsus I and II, this character is manifested as an abrupt break between ornamentation types, with distinctly ornamented and unornamented halves of the metatarsus separated by a demarcation resembling a suture (Fig. 13E). In other specimens, the shift is more subtle, with the distal half of the metatarsus bearing significant ornamentation that is nonetheless reduced in density with respect to the proximal half of the metatarsus. Hence, Boyer and Giribet (2007) coded the metatarsus II as fully ornamented in *A. daviesae* and *A. forsteri* (Juberthie 2000), species that we here consider non-uniformly ornamented.

Biogeography of *Austropurcellia*.—Like other Cyphophthalmi, *Austropurcellia* species display endemism on a very fine geographic scale, with each species currently known from just a small handful of localities all within 50 km of each other (Fig. 1). Therefore, we expect that exploration of forested areas throughout the Wet Tropics of Queensland will yield many new collecting sites and additional new species. For example, these animals have been collected in Daintree National Park at Cooper Creek and Emmagen Creek, but nowhere else within the 1200 km² of the park's area. Similarly, there are no known collecting localities within Girringun National Park or Paluma Range National Park. Species distribution modeling (also known as environmental or ecological niche modeling) could be used to make predictions about areas that would hold most promise for "prospecting" for new *Austropurcellia* localities.

The Wet Tropics represent the largest remnant of the Gondwana-derived rainforests that once dominated the entire continent of Australia, but declined throughout the Tertiary

(Adam 1992; BMR Paleogeographic Group 1990; Harrison & Dodson 1993; Nix 1991; Truswell 1993). Today the Wet Tropics is comprised of isolated "islands" of montane rainforest surrounded by warmer or more xeric habitats. The history of the area during the Last Glacial Maximum through the present has been well studied by researchers working within several different disciplines. Palynological, phylogeographic, and biogeographic data all indicate that much of the Quaternary rainforest in this region was severely contracted, confined to two isolated areas each of which contained many small refugia (Nix 1991; Kershaw 1994; Joseph et al. 1995; Schneider et al. 1998; Hugall et al. 2002, 2003). These findings are consistent with results from paleoclimate modeling, which predict that temperature and moisture regimes suitable for rainforest growth would have been fragmented and disjunct throughout the region during the Last Glacial Maximum (LGM) (Nix 1991; Graham et al. 2006). During the transition from cool-dry to cool-wet conditions, commencing approximately 8000 years ago, rapid expansion of the rainforest occurred, followed by another less severe contraction to produce the current distribution of forest habitat (Kershaw 1984; BMR Paleogeographic Group 1990; Hopkins et al. 1993).

In vertebrate groups, this recent history of climate change has resulted in a pattern of strong population divergence between "islands" of rainforest habitat (Joseph et al. 1995; Schneider and Moritz 1999; Schneider et al. 1999; Phillips et al. 2004). In particular, major genetic divergences coincide geographically with a feature known as the Black Mountain Corridor (BMC) (Fig. 1), a large dry area separating the Carbine and southern Atherton Tablelands 18,000 years ago that is predicted by paleoclimate modeling (Winter 1984; Nix 1991; Hugall et al. 2002; Graham et al. 2006).

It is predicted that small, slow-dispersing invertebrate taxa should display phylogenetic and/or phylogeographic structure at a finer geographic scale than more vagile vertebrates (Moritz et al. 2001). A limited number of published studies of Wet Tropics fauna support this hypothesis. The work of Bell et al. (2004, 2007) on the Wet Tropics endemic dung beetle genus *Tenmoplectron* demonstrated that barriers between species coincide geographically with phylogeographic breaks found in vertebrates, and are likely explained by habitat fragmentation during the LGM. A landmark study by Hugall et al. (2002) investigated the phylogeographic relationships of the terrestrial gastropod *Gnarosoplia bellendenkerensis*, which is endemic to the Wet Tropics rainforests, using a spatially explicit approach incorporating paleoclimate modeling. They found that although there was a major genetic break associated with the BMC, it was one of only several deep divisions within the species (Hugall et al. 2002; Hugall et al. 2003).

Within *Austropurcellia*, the BMC marks a split not between populations or species, but rather between groups of species—though whether those groups represent evolutionary lineages is currently unknown. Within the Wet Tropics, four morphologically distinct species (*A. arctica* (Cantrell 1980), *A. forsteri* (Juberthie 2000), *A. scoparia* Juberthie 1988, and *A. vicina*) occur north of the BMC, and five occur south of the BMC (*A. alata*, *A. culminis*, *A. daviesae* (Juberthie 1989), *A. despectata*, and *A. woodwardi* (Forster 1955)) (Fig. 1), and there are almost certainly many more related species awaiting discovery, especially south of the BMC. Beyond the Wet Tropics, the

only described species of *Austropurcellia* is *A. capricornia* (Todd Davies 1977) (Fig. 1). At present, phylogenetic analysis of the family Pettalidae has not resolved relationships within *Austropurcellia* (Boyer & Giribet 2007, 2009). The addition of more individuals, more populations and more species to a molecular phylogenetic analysis of the genus could result in a robust evolutionary tree that would permit tests of hypotheses about the role of forest fragmentation during the LGM in driving the diversification of these cryptic dispersal-limited arachnids. In addition to a phylogeny, time calibration is essential in such tests. A recent phylogeny of the Opiliones calibrated with time points based on fossil harvestman concluded that the genus *Austropurcellia* is 102 Ma old, with a standard deviation of 16 Ma (Giribet et al. 2009). Given the great age of the lineage, and the ability of these animals to persist in tiny patches of appropriate habitat, the forest refugia of the LGM may have acted as museums rather than cradles of biodiversity in the case of the mite harvestmen.

TAXONOMY

Family Pettalidae

Genus *Austropurcellia* Juberthie 1988

Austropurcellia Juberthie 1988:133, Boyer & Giribet 2007:347.

Type species.—*Austropurcellia scoparia* Juberthie 1988, by original designation.

Diagnosis.—We use the generic diagnosis formulated by Boyer & Giribet (2007), with one modification. Although those authors state that scopulae are absent from tergite VIII, Todd Davies' (1977) description of *A. capricornia* does depict scopulae emerging from tergite VIII. Ozophores in dorsal 45° position. Eyes present, incorporated into ozophores, without

lenses. No projections surrounding gonostome. Male exocrine glands may be present in anal region. Scopulae present on anal plate. Tergite IX divided. Robust ventral process on the proximal article of the chelicerae absent; prominent apodeme on the distal article of chelicerae. Prominent ventral process on trochanter of palp. Solea in tarsus I. Male tarsus IV bisegmented dorsally to fully bisegmented. Adenostyle extremely robust, with height no more than twice base length.

Taxonomic history.—The first mite harvestman discovered in Australia, *Rakaia woodwardi*, was described from the Wet Tropics by Forster (1955). Two additional species from Queensland, *Neopurcellia capricornia* Todd Davies 1977 and *Rakaia arctica* Cantrell 1980, were described more than two decades later, and Juberthie (1989, 2000) subsequently added *R. daviesae* Juberthie 1989 and *N. forsteri* Juberthie 2000. Juberthie (1988) also described the monotypic genus *Austropurcellia* (type species *scoparia*) from Queensland. The genera *Rakaia* and *Neopurcellia* as originally described also included species from New Zealand, but recent phylogenetic analyses have demonstrated that the Queensland species comprise a monophyletic group and are more closely related to each other than they are to New Zealand taxa. As a result, all Queensland *Rakaia* and *Neopurcellia* have been transferred to *Austropurcellia* by Boyer and Giribet (2007), who also re-evaluated all morphological characters previously thought to be of taxonomic significance and developed a new diagnosis for the genus.

Species account and distribution.—Ten valid species (including the four new species described here) are known, all occurring in Queensland, Australia. Nine of the ten occur within the Australian Wet Tropics, with *A. capricornia* known from further south at Finch Hatton, near Mackay (Fig. 1).

KEY TO THE KNOWN SPECIES OF *AUSTROPURCELLIA*

- | | |
|--|-----------------------|
| 1. Male tarsus IV fully divided | 2 |
| Male tarsus IV partially divided | 8 |
| 2. Triangular projections emerging laterally from tergite VIII | <i>A. alata</i> |
| Tergite VIII without lateral projections | 3 |
| 3. Scopulae emerging from tergite VIII | <i>A. capricornia</i> |
| Tergite VIII without scopulae | 4 |
| 4. Scopula emerging from anterior margin of anal plate | <i>A. scoparia</i> |
| Anterior margin of anal plate without scopula | 5 |
| 5. Twisted scopula emerging from center of anal plate | <i>A. vicina</i> |
| Center of anal plate without scopula | 6 |
| 6. Anal plate bilobed posteriorly with central posterior scopula | 7 |
| 7. Long scopula emerging from posterior margin of anal plate to cover part of tergite VIII | <i>A. forsteri</i> |
| Small scopula not extending past anal plate | <i>A. culminis</i> |
| 8. Anal plate without distended protrusions on anterior margin | 9 |
| Anal plate with distended protrusions on anterior margin | 10 |
| 9. Long scopula emerging from posterior margin of anal plate to cover part of tergite VIII | <i>A. arctica</i> |
| Small scopula not extending past posterior margin of the anal plate | <i>A. daviesae</i> |
| 10. Thick median scopula | <i>A. woodwardi</i> |
| Small twisted central scopula | <i>A. despectata</i> |

Austropurcellia alata new species

Figs. 2–5

Type.—Holotype male, 20 km S of Ravenshoe, Queensland, Australia, 1900 m, 17°49'S, 145°32'E, 3 July 1971, Taylor and Feehan, ANIC berlesate 358 (ANIC).

Other material examined.—The only known specimen beyond the holotype is the one individual photographed during this study (Figs. 2A–C), which was subsequently lost inside equipment during environmental SEM.

Etymology.—Latin adjective: *alata* = winged. The specific epithet refers to the unusual lateral projections of tergite VIII.

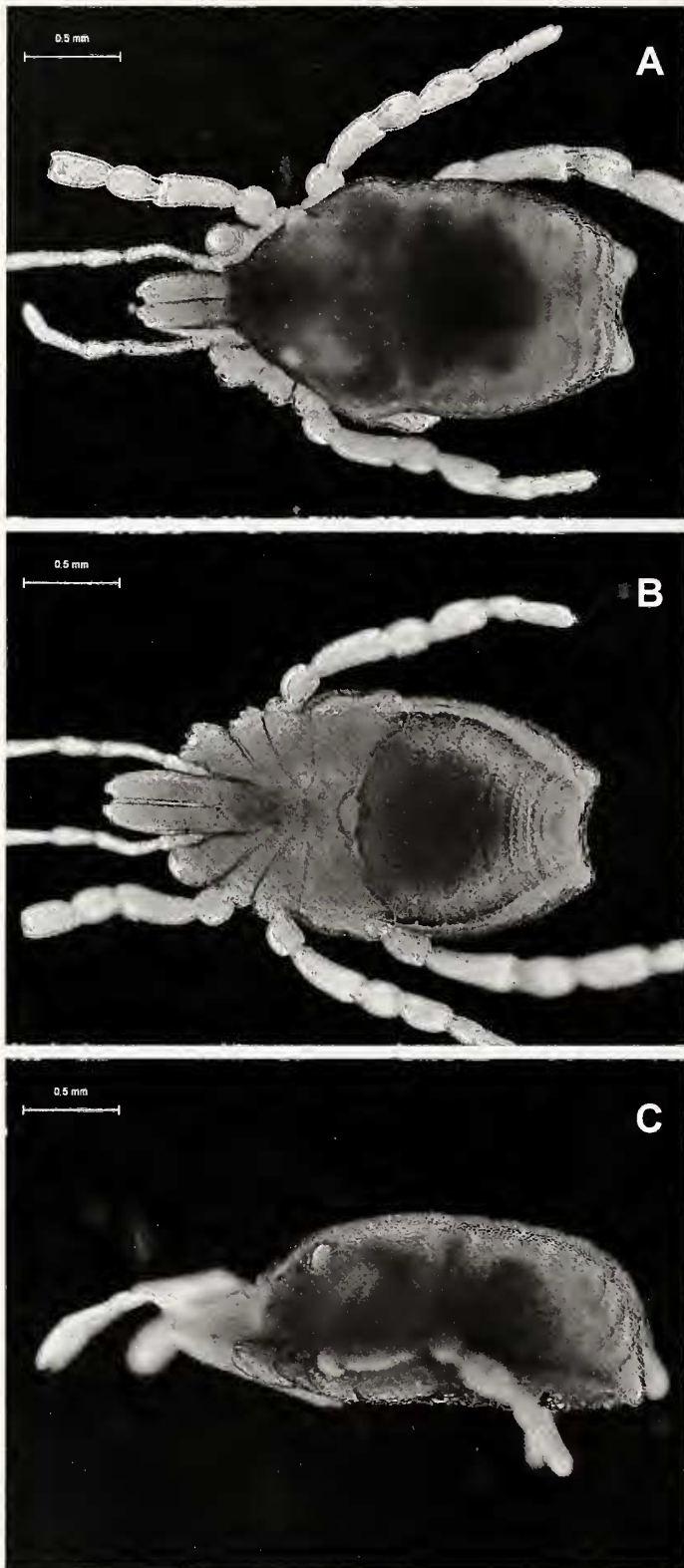


Figure 2.—*Austropurcellia alata* n. sp., male holotype: A. Dorsal view; B. Ventral view; C. Lateral view. Scale bars = 500 μ m.

Diagnosis.—Pettalid with dorsal scutum flat (Figs 2A, 3A). Trochanter of palp with conspicuous ventral process (Fig. 5A). Scopulae originating from center of anal plate, but not observed in either specimen examined (Figs. 3B, 4C). Prominent lateral projections emerging from tergite VIII

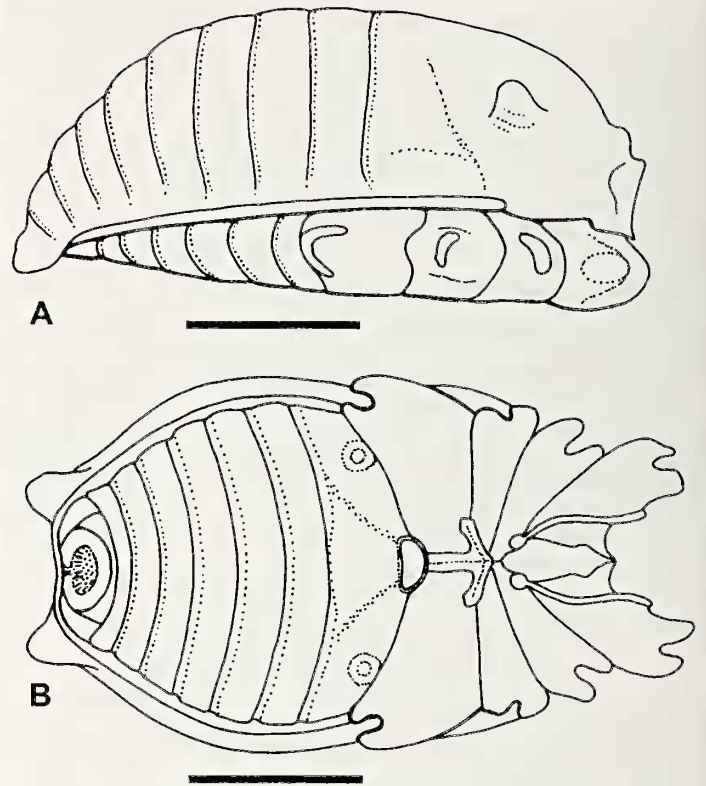


Figure 3.—*Austropurcellia alata* n. sp., male holotype: A. Lateral view; B. Ventral view. Scale bars = 500 μ m.

(Figs. 3B, 4C). Tarsus bisegmented with triangular adenostyle (Fig. 5G).

Description.—Total length of male holotype 2.24, greatest width 1.27 mm. Body brown-yellow (in alcohol), with most of the dorsal surface and legs showing a tuberculate-granulate microstructure (Figs. 4A, B). Anterior margin of dorsal scutum with unusual prominent postero-lateral projections; prosomal region trapezoidal (Figs. 3B, 4A, B). Ozophores conical positioned at a 45° angle (Fig. 4A). Transverse opisthosomal sulci distinct by lacking granulation (Fig. 4A). Longitudinal opisthosomal sulcus present in posterior-most region of the animal (Fig. 4A). Dorsal scutum flat; opisthosomal region reaching its maximum width at segment II (Figs. 3B, 4A, B).

Coxae of legs I and II mobile; coxae of remaining legs fixed. Ventral proosomal complex of male with coxae II–IV meeting in the midline (Figs. 3B, 4B). Male gonostome small, subtriangular, wider than long, bordered on posterior margin by the first opisthosomal sternite; male gonostome shorter than length of seam of contact of left and right coxae IV parallel to midline (Fig. 4D). No female specimens available.

Spiracles C-shaped (sensu Giribet and Boyer 2002), with both edges recurving internally as found in the “open circle” type (Fig. 4E). Sternal opisthosomal region without modifications or glandular pores (Fig. 4D). Anal region with sternites 8 and 9 and tergite IX free, not forming a corona analis (Figs. 3B, 4C). Area of contact of tergite IX and sternite 9 of “pettalid” type (Giribet and Boyer 2002), in which tergite IX laterally covers sternite 9 and clearly meets sternite 8 (Figs. 3B, 4C). Anal plate of male with central scopula apparently present but broken off in both male specimens

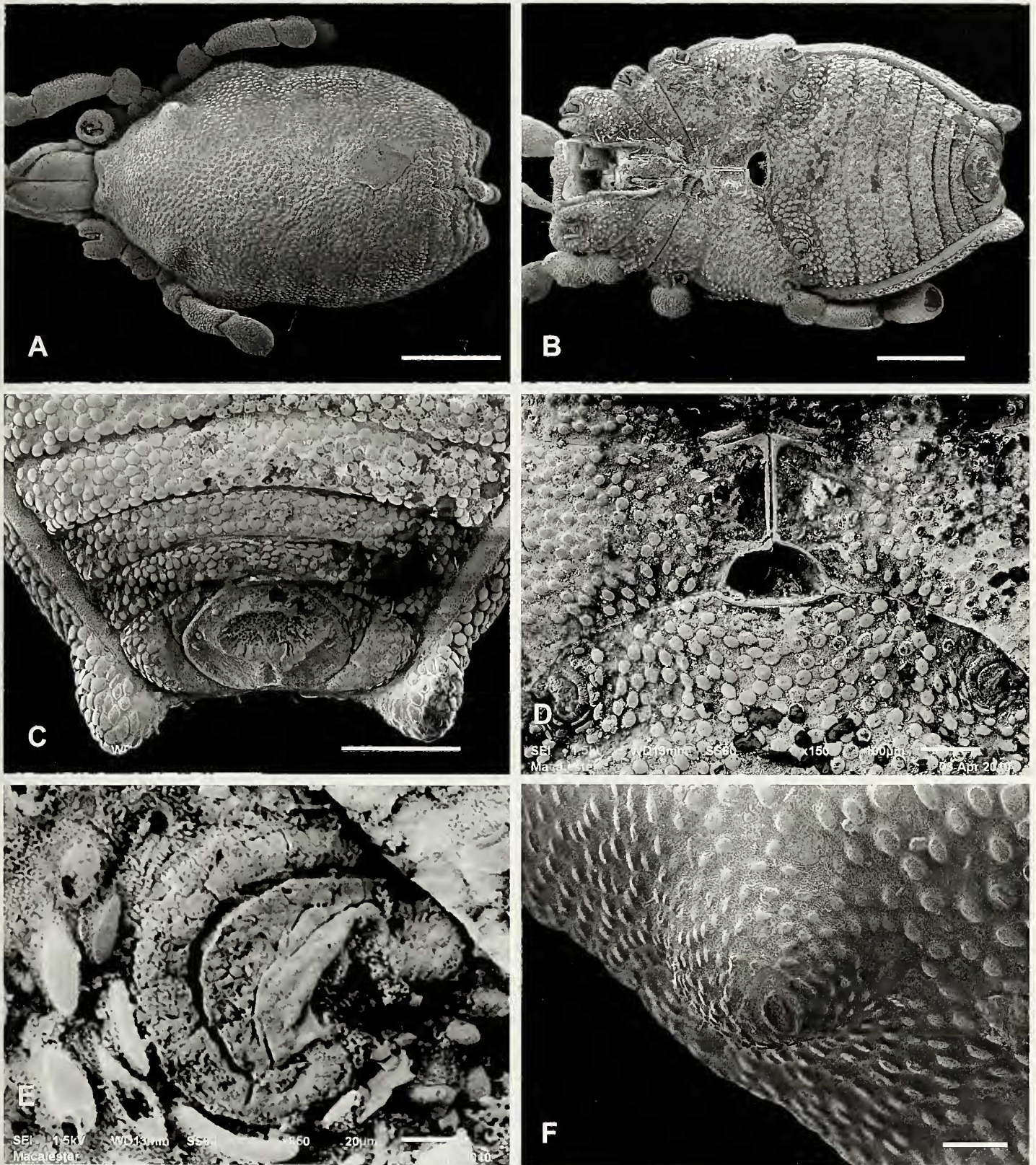


Figure 4.—*Austropurcellia alata* n. sp: A. Male paratype, dorsal view, scale bar = 500 μ m; B. Male holotype, ventral view, scale bar = 500 μ m; C. Male holotype, posterior ventral view, scale bar = 200 μ m; D. Male holotype, gonostome and sternal area, scale bar = 100 μ m; E. Male holotype, spiracle, scale bar = 20 μ m; F. Male paratype ozophore, scale bar = 50 μ m.

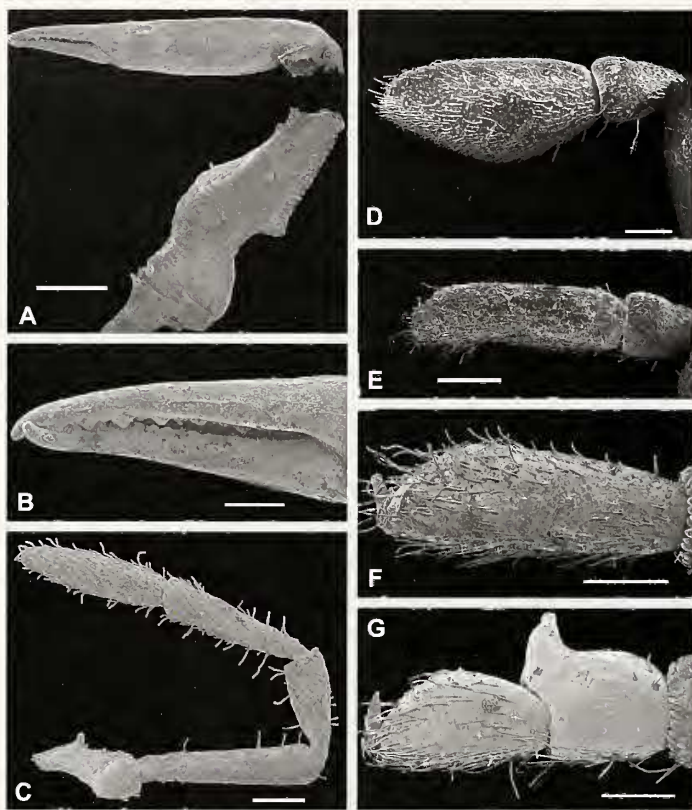


Figure 5.—*Austropurcellia alata* n. sp., male holotype: A. Chelicera, scale bar = 200 μ m; B. Detail of chelicerae, scale bar = 200 μ m; C. Palp, scale bar = 100 μ m; D. Tarsus I; E. Tarsus II; F. Tarsus III. G. Tarsus IV; scale bar = 100 μ m for all tarsi.

examined (Fig. 4C). Cuticle with granulate surface in all ventral areas except for anal plate (Figs. 4A–C). No anal glandular pores visible.

Chelicerae short and extremely robust. Proximal article of chelicerae with dorsal crest [“dorsal ridge” of Hansen and Sorensen (1904) and Forster (1948); “dorsal transverse crest” of Juberthie (1970)], without ventral process (Fig. 5A). Two types of dentition, as is typical in pettalids (Fig. 5B).

Palp with a prominent ventral process on the trochanter (Fig. 5C).

Surface of most articles clearly ornamented with granules; all tarsi smooth (Figs. 5F, G) and metatarsi I and II partially ornamented (Figs. 5D, E). Ventral side of tarsus I with solea (Fig. 5D). Tarsus IV of the male bisegmented, bearing a large thick adenostyle projecting upward and slightly distally (Fig. 5G). Measurements from holotype male of leg articles from proximal to distal (given in μ m): leg I – 218, 554, 212, 417, 172, 443; leg II – 175, 440, 174, 352, 112, 375; leg III – 179, 356, 167, 334, 152, 315; leg IV – 311, 505, 303, 390, 165, 423.

Remarks.—*Austropurcellia alata* is known only from the type locality in the Atherton Tableland of north-eastern Queensland.

Austropurcellia culminis new species

Figs. 6–9

Types.—Holotype male, Bellenden Ker Summit, 1500 m, 40 km SSE of Cairns, Queensland, Australia, 17°14'S, 145°51'E,

20–22 January 1992, I.D. Burekhardt (QM 90599). Paratypes: 5 males, 8 females, 1 juvenile, collected with holotype (MHNG).

Etymology.—Latin noun: culminis = of the summit. The specific epithet refers to the type locality of the species, the summit of Bellenden Ker. This species is very similar to *A. daviesae*, which is found at several lower-altitude localities.

Diagnosis.—Pettalid with dorsal scutum flat (Figs. 6A, 7A). Trochanter of palp with conspicuous ventral process (Figs. 9C, D); chelicerae with robust apodeme (Fig. 9A); tarsus I with distinct solea (Fig. 9E). Scopulae emerging from center of anal plate (Fig. 8C). Male tarsus IV smooth and fully bisegmented with thick triangular adenostyle (Fig. 9H).

Description.—Total length of male holotype 1.5 mm, greatest width 0.8 mm. Body brown-yellow (in alcohol), with most of the dorsal surface and legs showing a tuberculate-granulate microstructure (Figs. 8A, B). Anterior margin of dorsal scutum without projections. Ozophores conical positioned at a 45° angle. Transverse opisthosomal sulci distinct by lacking granulation; longitudinal sulcus absent (Fig. 8A). Dorsal scutum flat; opisthosomal region reaching its maximum width at segment II (Figs. 7B, C, 8A, B).

Coxae of legs I and II mobile; coxae of remaining legs fixed. Ventral prosomal complex of male with coxae II–IV meeting in the midline (Fig. 7B). Male gonostome small, subtriangular, wider than long, bordered on posterior margin by the first opisthosomal sternite; male gonostome shorter than length of seam of contact of left and right coxae IV parallel to midline (Fig. 8D). Ventral prosomal complex of female with only coxae II meeting at the midline. Female gonostome roughly round in shape, with the edges of coxae of leg IV and first opisthosomal sternite forming a partial “tube” at the posterior margin of the opening.

Spiracles C-shaped (sensu Giribet and Boyer 2002) (Fig. 8E). Sternal opisthosomal region without modifications or glandular pores. Anal region with a partial corona analis: sternites 8 and 9 and tergite IX fused, although tergite IX is bisegmented. Anal region with sternites 8 and 9 and tergite IX free, not forming a corona analis. Area of contact of tergite IX and sternite 9 of “pettalid” type (Giribet and Boyer 2002) in which tergite IX laterally covers sternite 9 and clearly meets sternite 8. Anal plate of male with small central scopula (Fig. 8C). Cuticle with granulate surface in all ventral areas (Figs. 8A, B). Anal glandular pore not visible.

Chelicerae short and extremely robust (Fig. 9A). Proximal article of chelicerae with dorsal crest (“dorsal ridge” of Hansen and Sorensen (1904) and Forster (1948); “dorsal transverse crest” of Juberthie (1970)), without ventral process (Fig. 9A). Distal article of chelicerae with a conspicuous apodeme (Fig. 9A). Two types of dentition on mobile article of chelicerae, as is typical of pettalids (Fig. 9B).

Palp with a prominent ventral process on the trochanter (Fig. 9C, D).

Legs with all claws smooth, without ventral dentition or lateral pegs. In legs I and II the metatarsus is partially ornamented and the tarsus is smooth, while in legs III and IV the metatarsus is fully ornamented and the tarsus is smooth (Figs. 9E–H). Ventral side of tarsus I with solea (Fig. 9E). Tarsus IV of the male fully bisegmented, bearing a large thick adenostyle (Fig. 9H). Tarsus IV of the female without modifications. Measurements from holotype male of leg

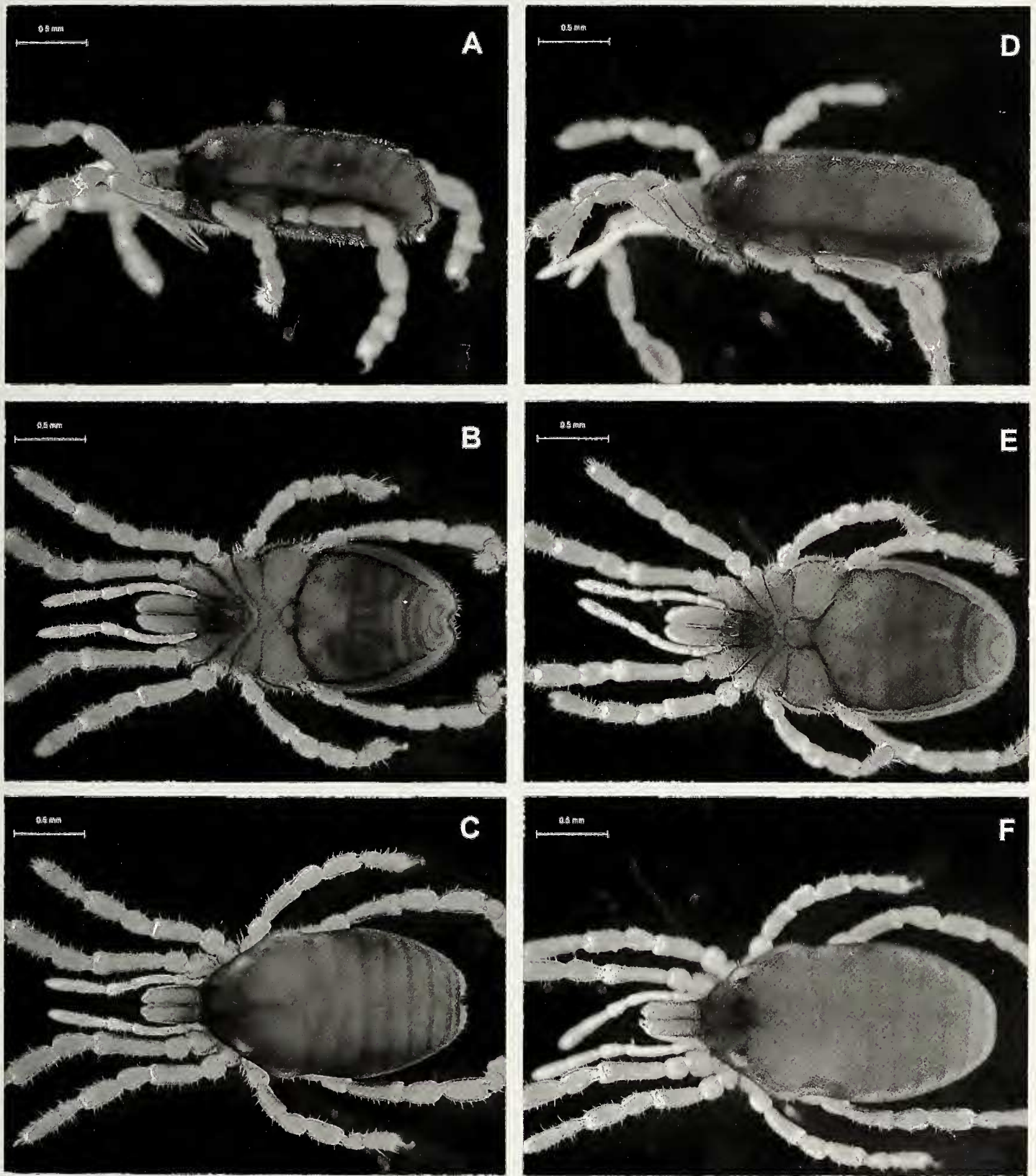


Figure 6.—*Austropurcellia culminis* n. sp., male holotype and female paratype: A. Male, lateral view; B. Male, ventral view; C. Male, dorsal view; D. Female, lateral view; E. Female, ventral view; F. Female, dorsal view. Scale bars = 500 μ m.

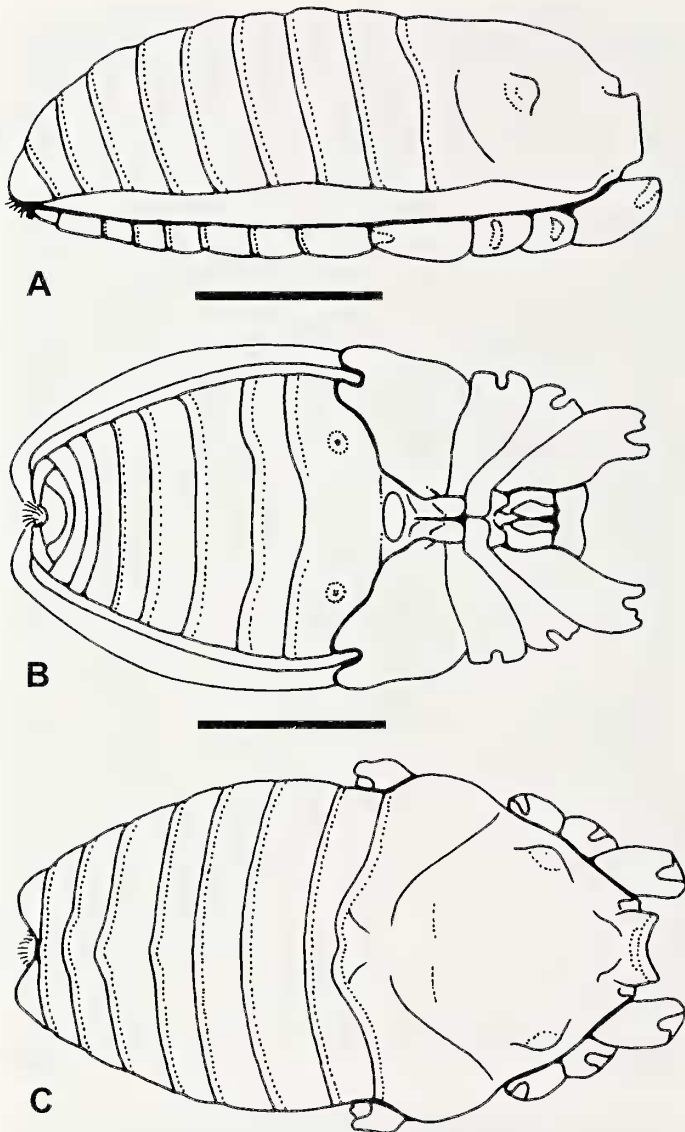


Figure 7.—*Austropurcellia culminis* n. sp., male holotype: A. Lateral view; B. Ventral view; C. Dorsal view. Scale bars = 500 μ m.

articles from proximal to distal (given in μ m): leg I – 149, 478, 234, 364, 161, 372; leg II – 128, 380, 201, 266, 138, 334; leg III – 131, 308, 140, 252, 136, 295; leg IV – 280, 341, 197, 328, 138, 342.

Remarks.—*Austropurcellia culminis* is known only from the type locality at the summit of Bellenden Ker.

Austropurcellia despectata new species

Figs. 10–13

Types.—Holotype male, from Millaa Millaa, Queensland, Australia, 17°31'S, 145°37'E (estimated), 15 May 1990, I.D. Naumann, J.C. Cardale, ANIC berlesate 674 (ANIC). Paratypes: 1 adult male, 1 subadult male 1 juvenile, collected with holotype (ANIC).

Etymology.—Latin adjective: *despectata* = touristed, viewed, observed. The specific epithet refers to the much-visited and oft-photographed waterfalls for which Millaa Millaa, the type locality for the species, is famous.

Diagnosis.—Pettalid with dorsal scutum flat (Figs. 10A, 11A). Trochanter of palp with conspicuous ventral process (Fig. 13D); chelicerae with robust apodeme (Fig. 13A). Anal

plate with small central scopula and two smooth anterior protrusions easily visible in lateral view (Figs. 10A, 11A, 12C). Metatarsi I and II with non-ornamentation that is lighter distally than proximally, and tarsi I and II lightly ornamented in basal-most area (Figs. 13E–H). Tarsus IV with light ornamentation in basal-most area, and partially bisegmented with thick triangular adenostyle (Fig. 13H).

Description.—Total length of male holotype 1.9 mm, greatest width 1.3 mm. Body brown-yellow (in alcohol), with most of the dorsal surface and legs showing a tuberculate-granulate microstructure (Figs. 12A, B). Anterior margin of dorsal scutum without projections. Ozophores conical positioned at a 45° angle. Transverse and longitudinal opisthosomal sulci distinct by lacking granulation (Fig. 12A). Dorsal scutum flat; opisthosomal region reaching its maximum width at segment II (Fig. 11B, C, 12A, B).

Coxae of legs I and II mobile; coxae of remaining legs fixed. Ventral prosomal complex of male with coxae II, III, and IV meeting in the midline (Figs. 11B, 12B). Male gonostome small, subtriangular, wider than long, bordered on posterior margin by the first opisthosomal sternite; male gonostome shorter than length of seam of contact of left and right coxae IV parallel to midline (Fig. 12D). No female specimens available for examination.

Spiracles C-shaped (sensu Giribet and Boyer 2002) (Fig. 12E). Sternal opisthosomal region without modifications or glandular pores. Anal region with sternites 8 and 9 and tergite IX free, not forming a corona analis (Fig. 12C). Area of contact of tergite IX and sternite 9 of “pettalid” type (Giribet and Boyer 2002) in which tergite IX laterally covers sternite 9 and clearly meets sternite 8 (Fig. 12C). Anal plate of male with central scopula and two distinctive ventral swellings anterior to scopula (Fig. 12C). Cuticle with granulate surface in all ventral areas except for anal plate (Fig. 12C). Anal glandular pore located at junction of tergites VIII, IX, and anal plate (Fig. 12C).

Chelicerae short and extremely robust (Fig. 13A). Proximal article of chelicerae with dorsal crest [“dorsal ridge” of Hansen and Sørensen (1904) and Forster (1948); “dorsal transverse crest” of Juberthie (1970)], without ventral process (Fig. 13A). Distal article of chelicerae with a conspicuous apodeme (Fig. 13A). Two types of dentition, as is typical of pettalids (Fig. 13B).

Palp with a prominent ventral process on the trochanter (Fig. 13D).

Legs with all claws smooth, without ventral dentition or lateral pegs. Metatarsus I fully ornamented and tarsus I lightly ornamented in the basal-most area; metatarsus II partially ornamented and tarsus II smooth; metatarsus III completely ornamented and tarsus III smooth; metatarsus completely ornamented and tarsus IV lightly ornamented in basal-most area (Figs. 13E, F). Ventral side of tarsus I with solea (Fig. 13E). Tarsus IV of the male partially bisegmented, bearing a large thick adenostyle projecting upward (Fig. 13H). Measurements from holotype male of leg articles from proximal to distal (given in μ m): leg I – 167, 480, 214, 323, 138, 362; leg II – 155, 389, 166, 287, 130, 323; leg III – 160, 328, 169, 260, 129, 311; leg IV – 220, 437, 220, 324, 137, 370.

Remarks.—*Austropurcellia despectata* is known only from the type locality in Millaa Millaa.

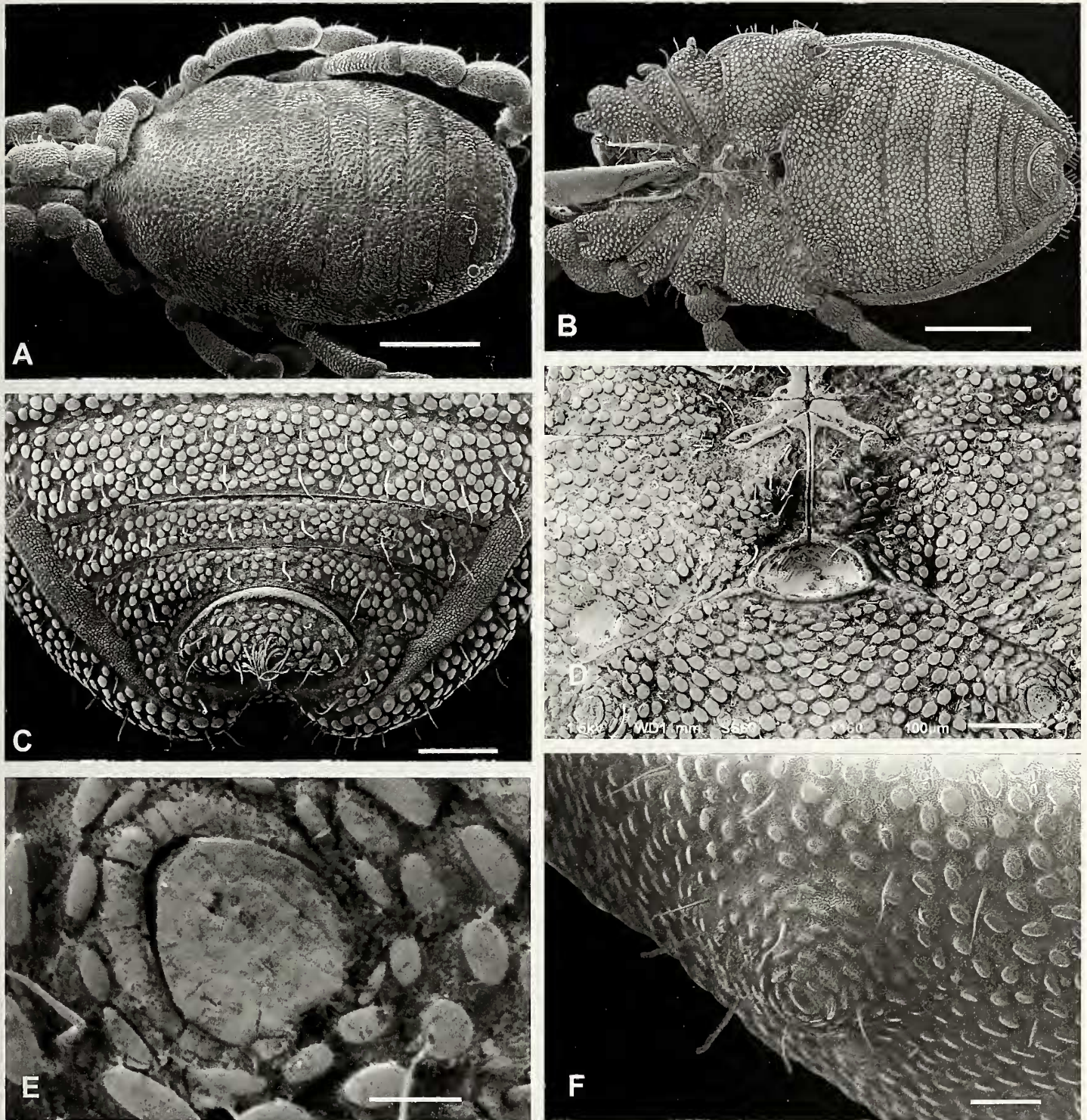


Figure 8.—*Austropurcellia culminis* n. sp., male paratype: A. Dorsal view, scale bar = 400 μ m; B. Ventral view, scale bar = 400 μ m; C. Posterior ventral region, scale bar = 100 μ m; D. Gonostome area, scale bar = 100 μ m; E. Spiracle, scale bar = 20 μ m; F. Ozophore, scale bar = 50 μ m.

Austropurcellia vicina new species

Figs. 14–16

Types.—Holotype male, Mt. Lewis via Julatten, 16°34'S, 145°18'E (estimated), 21 May 1980, I.D. Naumann, J.C. Cardale; ANIC berlesate 679 (ANIC). Paratype: 1 male, collected with holotype (ANIC).

Etymology.—Latin noun, vicina = neighbor. The specific epithet refers to this species' proximity to the type locality for the genus, which is Julatten.

Diagnosis.—Pettalid with dorsal scutum flat (Figs. 14C, 15C). Trochanter of palp with conspicuous ventral process (Fig. 17B); chelicerae with robust apodeme (Fig. 17A), tarsus

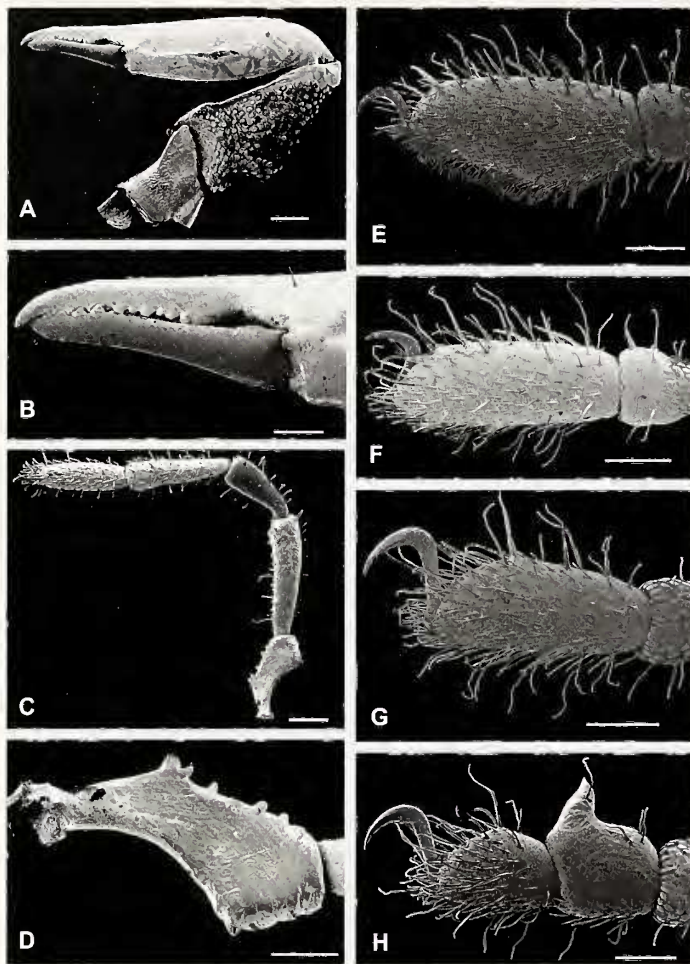


Figure 9.—*Austropurcellia culminis* n. sp., male paratype: A. Chelicerae, scale bar = 100 μ m; B. Detail of chelicerae, scale bar = 50 μ m; C. Palp, scale bar = 100 μ m; D. Trochanter of palp, scale bar = 50 μ m; E. Tarsus I; F. Tarsus II. G. Tarsus III; H. Tarsus IV; scale bar = 100 μ m for all tarsi.

I with distinct solea (Fig. 17C). Scopulae emerging from center of anal plate (Fig. 16B). Tarsus fully bisegmented with thick triangular adenostyle (Fig. 17F).

Description.—Total length of male paratype 1.27 mm at widest, 1.92 mm long. Body brown-yellow (in alcohol), with most of the dorsal surface and legs showing a tuberculate-granulate microstructure (Fig. 16A). Anterior margin of dorsal scutum without projections (Figs. 16A, B). Ozophores conical and positioned at a 45° angle. Transverse and longitudinal opisthosomal sulci distinct by lacking granulation. Dorsal scutum flat; opisthosomal region reaching its maximum width at segment II (Figs. 15B, C).

Coxae of legs I and II mobile; coxae of remaining legs fixed. Ventral prosomal complex of male with coxae II–IV meeting in the midline (Fig. 16D). Male gonostome small, subtriangular, wider than long, bordered on posterior margin by the first opisthosomal sternite; male gonostome shorter than length of seam of contact of left and right coxae IV parallel to midline (Fig. 16D).

Spiracles C-shaped (sensu Giribet and Boyer 2002) (Fig. 16C). Sternal opisthosomal region without modifications or glandular pores. Anal region without a corona analis, with tergite IX bisegmented. Area of contact of tergite IX and

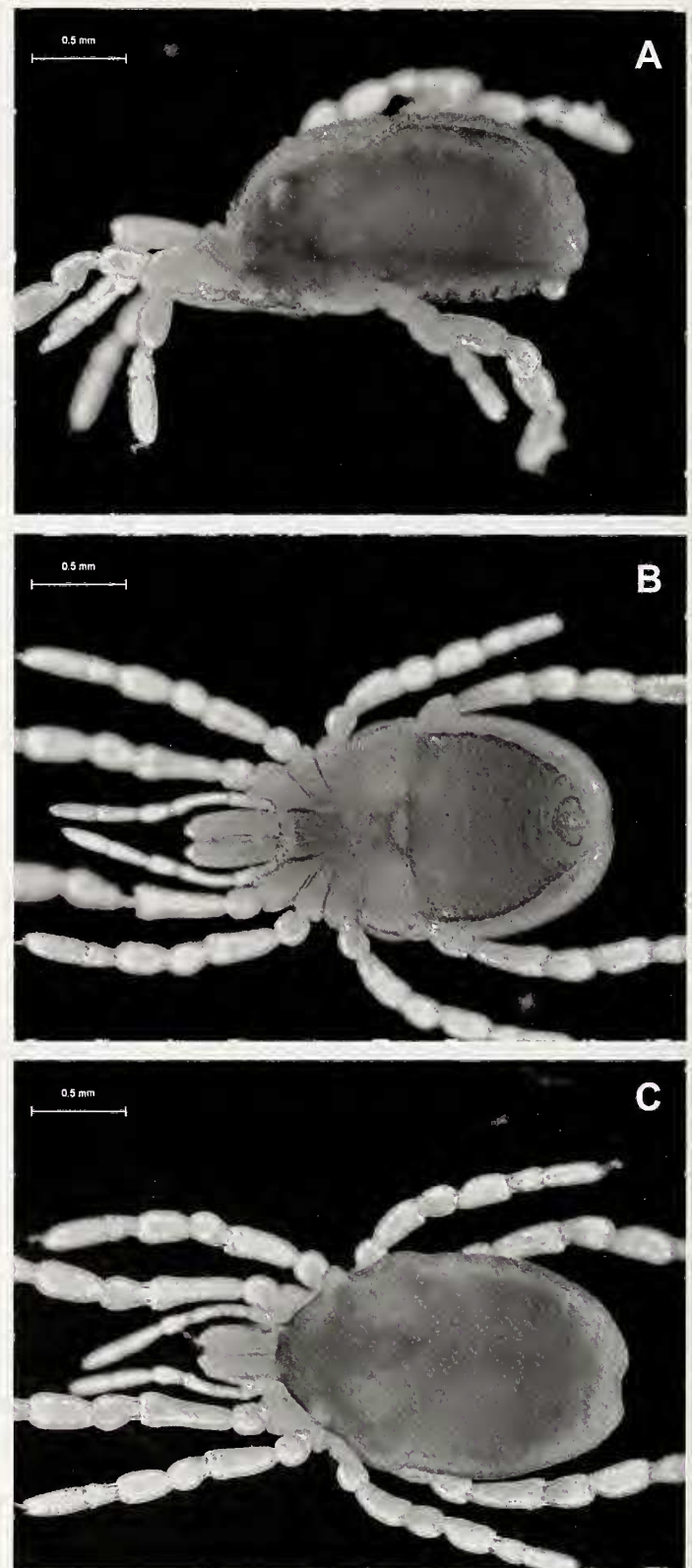


Figure 10.—*Austropurcellia despectata* n. sp., male holotype: A. Lateral view; B. Ventral view; C. Dorsal view. Scale bars = 500 μ m.

sternite 9 of the “pettalid” type (Giribet and Boyer 2002) in which tergite IX laterally covers sternite 9 and clearly meets sternite 8 (Fig. 16B). Anal plate of male with large, twisted central scopula (Fig. 16B). Cuticle with granulate surface in all

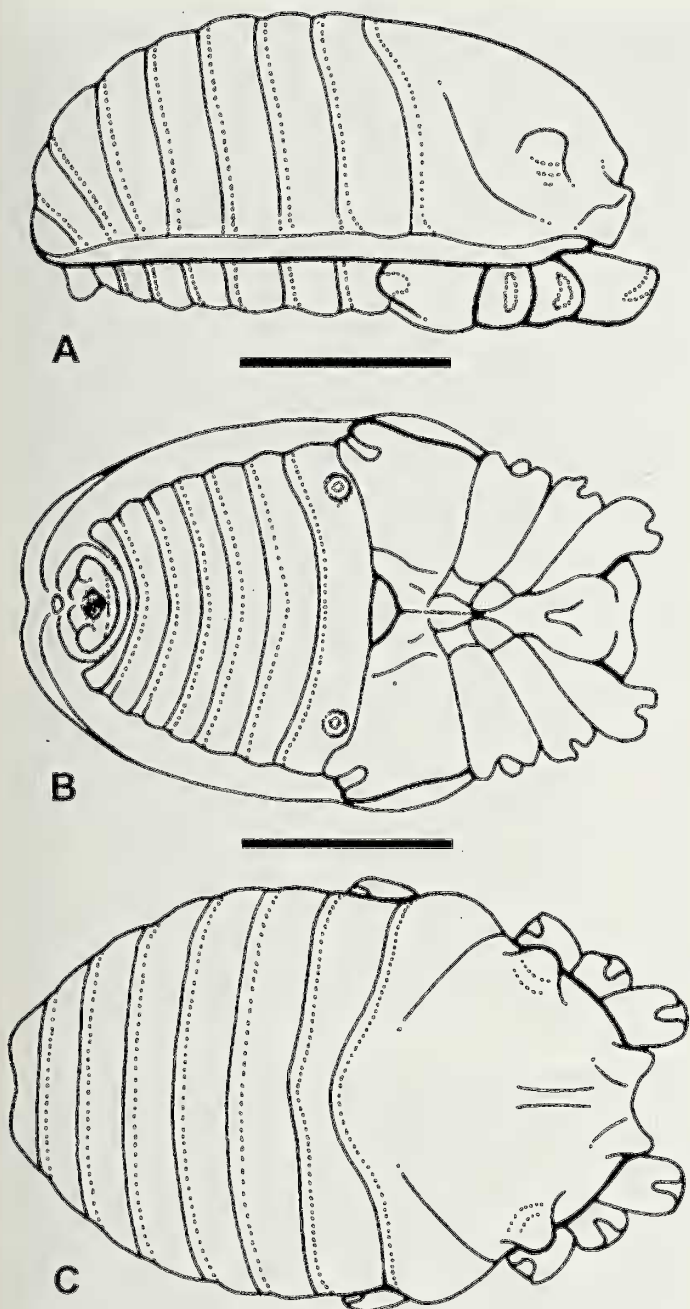


Figure 11.—*Austropurcellia despectata*, n. sp. male holotype: A. Lateral view; B. Ventral view; C. Dorsal view. Scale bars = 500 μ m.

ventral areas (Fig. 16A). Anal glandular pore not visible (Fig. 16B).

Chelicerae short and extremely robust (Fig. 17A). Proximal article of chelicerae with dorsal crest ["dorsal ridge" of Hansen and Sørensen (1904) and Forster (1948); "dorsal transverse crest of Juberthie (1970)], without ventral process (Fig. 17A). Distal article of chelicerae with a conspicuous apodeme (Fig. 17A). Two types of dentition on mobile article of chelicerae, as is typical of pectalids.

Palp with a prominent ventral process on the trochanter (Fig. 17B).

Legs with all claws smooth, without ventral dentition or lateral pegs. In legs I and II the metatarsus is partially ornamented and the tarsus is smooth, while in legs III and IV

the metatarsus is fully ornamented and the tarsus is smooth (Figs. 17C–F). Ventral side of tarsus I with solea (Fig. 17C). Tarsus IV of the male fully bisegmented, bearing a large thick adenostyle (Fig. 17F). Measurements from holotype male of leg articles from proximal to distal (given in μ m): leg I – 145, 560, 260, 387, 145, 456; leg II – 162, 420, 222, 301, 145, 389; leg III – 102, 405, 200, 291, 157, 351; leg IV – 253, 440, 250, 360, 131, 444.

Remarks.—*Austropurcellia vicina* is known only from the type locality at Mt. Lewis, near Julatten.

ACKNOWLEDGMENTS

Jeff Thole (Macalester College) provided fabulous support for all SEM work associated with this project. Birgit Muehlenhaus (Macalester College) generated Fig. 1, and Julie Martinez generated all drawings. Initial examination of material with SEM was performed by the authors and Macalester College students enrolled in the Fall 2009 version of Biology 476 - Research in Biodiversity and Evolution: Ana Begej, Zoë Campbell, Katie Dittman, Jordan Eckstein, Elise Griffin, Jessica Ramirez, and Cheryl Zogg. SLB abused the patience of curators at the Queensland Museum, and especially Peter Schwendinger of the Muséum d'Histoire Naturelle, Geneva, by hanging onto specimens for years beyond the end of loans; she offers apologies and thanks! Laura Leibensperger and Jerome Muriene (Harvard Museum of Comparative Zoology) helped with transfer of loans to SLB. Associate Professor of Classics Beth Severy-Hoven (Macalester College) provided advice and suggestions for Latin species names for these animals. Caitlin Baker (Macalester College) estimated coordinates for many localities. Gonzalo Giribet (Harvard University) provided helpful feedback throughout this project. Funding for this research was provided by Macalester College and National Science Foundation Grant 1020809 to SLB.

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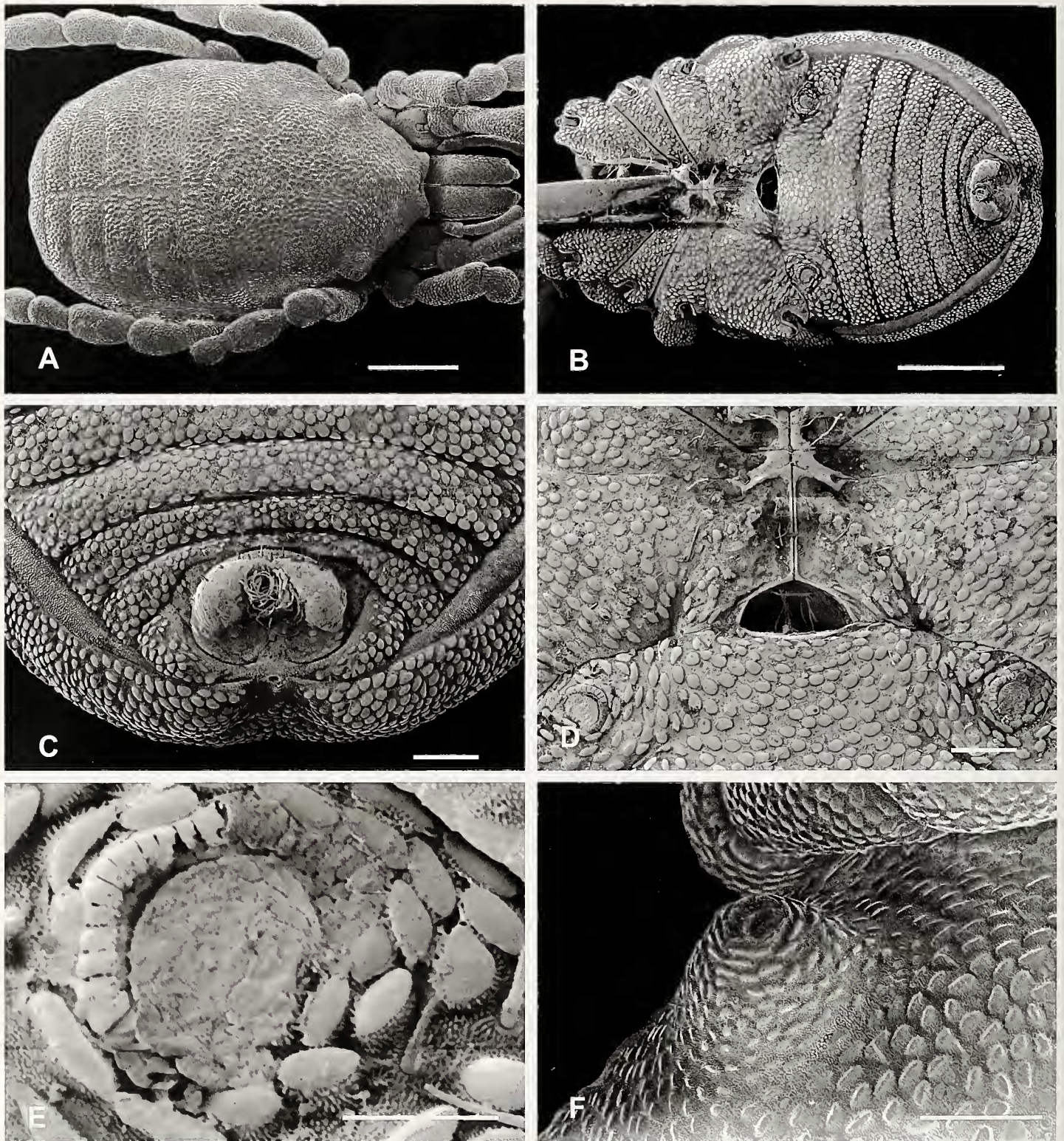


Figure 12.—*Austropurcellia despectata* n. sp., male paratype: A. Dorsal view, scale bar = 400 μ m; B. Ventral view, scale bar = 400 μ m; C. Posterior ventral region, scale bar = 100 μ m; D. Gonostome and sternal area, scale bar = 100 μ m; E. Spiracle, scale bar = 40 μ m; F. Ozophore, scale bar = 100 μ m.

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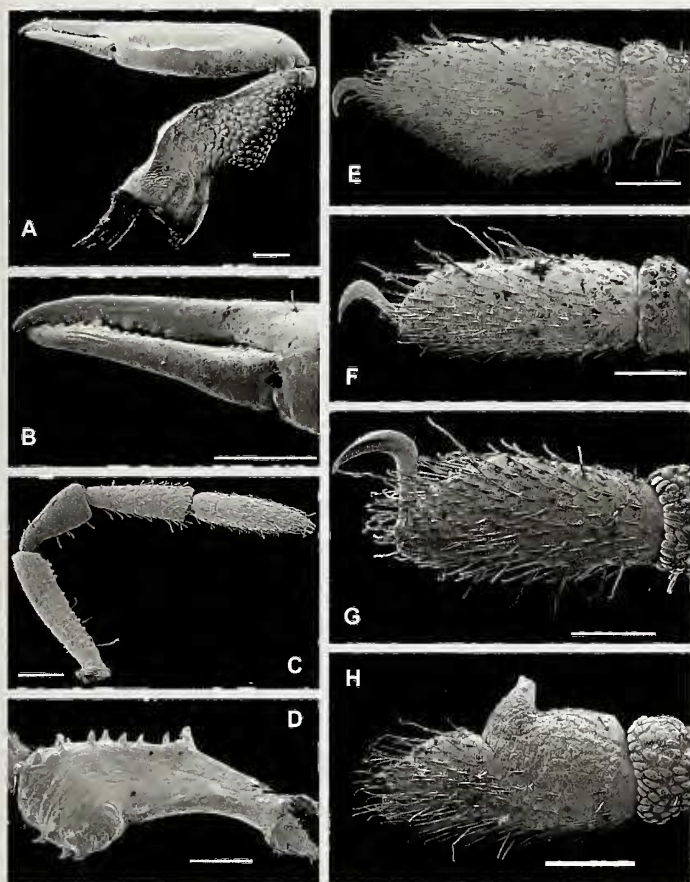


Figure 13.—*Austropurcellia despectata* n. sp., male paratype: A. Chelicerae, scale bar = 100 μ m; B. Detail of chelicerae, scale bar = 100 μ m; C. Palp, scale bar = 100 μ m; D. Trochanter of palp, scale bar = 50 μ m; E. Tarsus I; F. Tarsus II; G. Tarsus III; H. Tarsus IV; scale bar on all tarsi = 100 μ m.

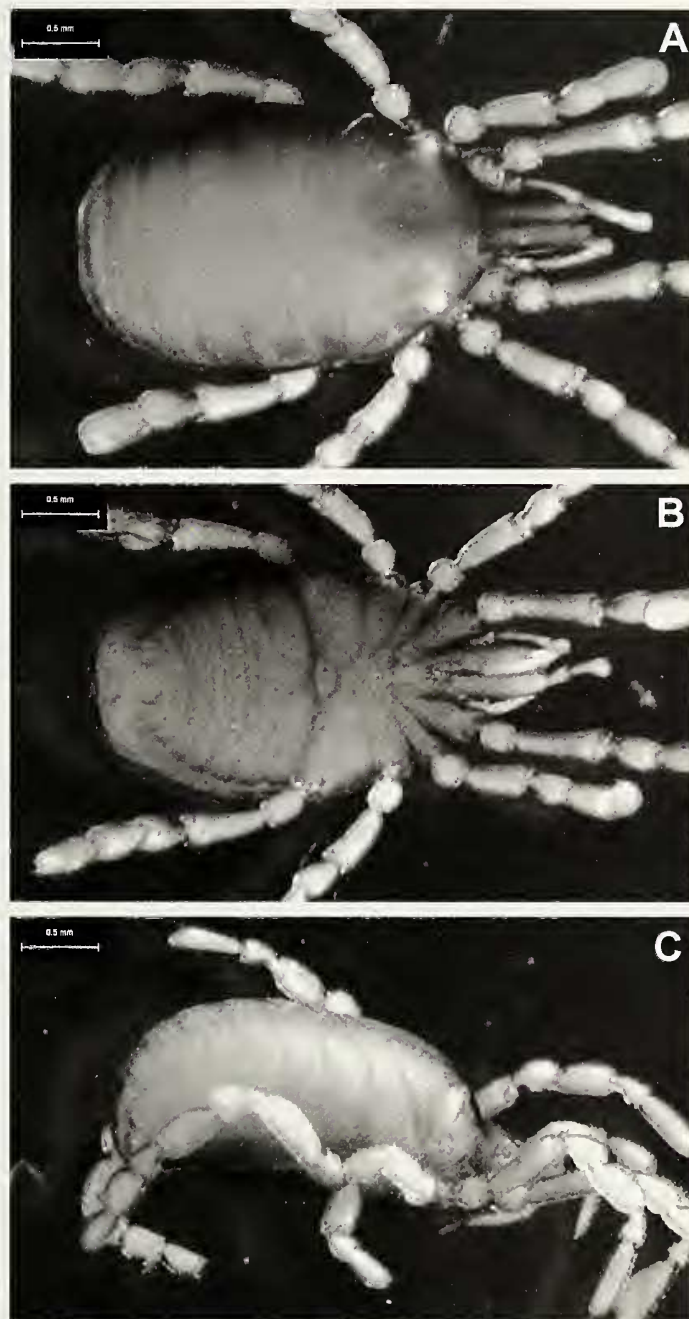


Figure 14.—*Austropurcellia vicina* n. sp., male holotype: A. Lateral view; B. Ventral view; C. Dorsal view. Scale bars = 500 μ m.

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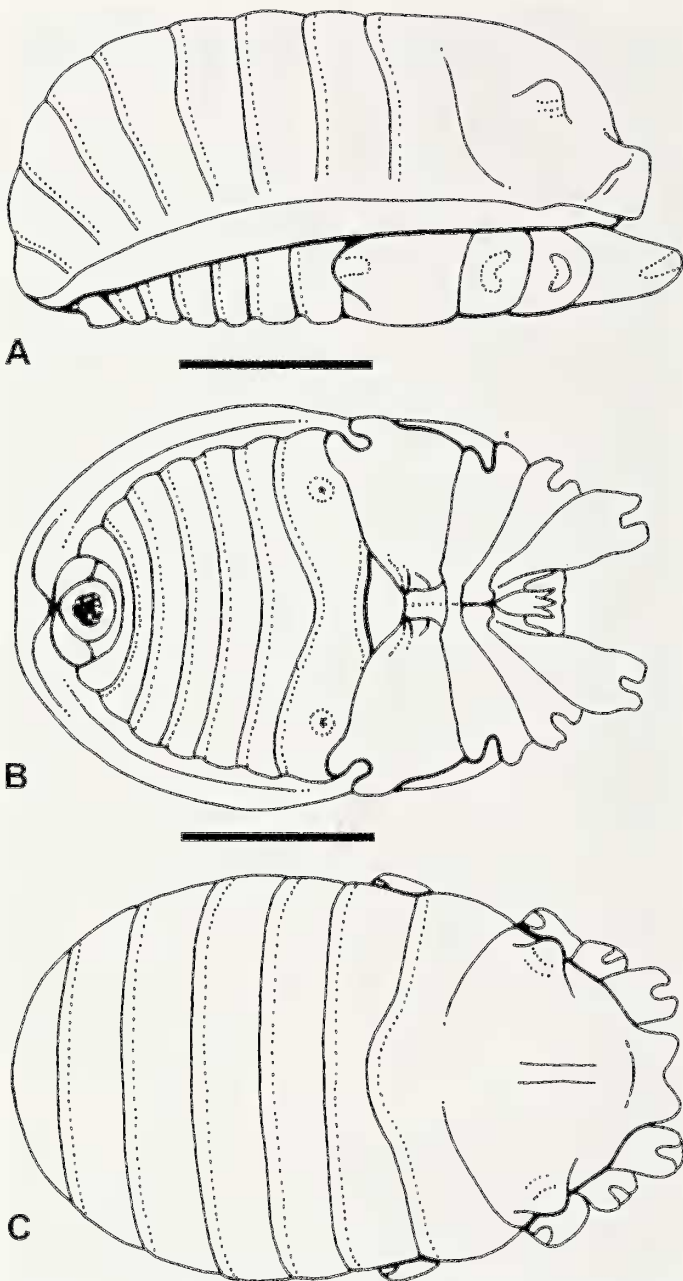


Figure 15.—*Austropurcellia vicina* n. sp., male holotype: A. Lateral view; B. Ventral view; C. Dorsal view. Scale bars = 500 μ m.

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Appendix 1.—Catalogue of *Austropurcellia* specimens, excluding species described in the current study.

Austropurcellia arctica (Cantrell 1980)

Rakaia arctica Cantrell 1980:241.

Type locality.—AUSTRALIA: *Queensland*: Cooper Creek, ca 21 km N of Daintree River, 16°10'S, 145°25'E (estimated), 14 November 1969, B.K. Cantrell (QM S334).

Paratype locality.—AUSTRALIA: *Queensland*: Noah Creek, 16°07'S, 145°25'E, 21 June 1971, Taylor and Feehan, ANIC Berlesate No. 321 (ANIC).

Additional collection.—AUSTRALIA: *Queensland*: Cooper Creek, Daintree National Park, Cape Tribulation, 16°09'58"S, 145°24'56.2"E, 15 February 2003, G. Giribet and C. D'Haese (MCZ DNA100951).

Austropurcellia capricornia (Todd Davies 1977)

Neopurcellia capricornia Todd Davies 1977:61.

Type locality.—AUSTRALIA: *Queensland*: Finch Hatton, 21°8'S, 148°37'E, (estimated), 10 April 1975, V. Davies and R. Kohout (QM W5765).

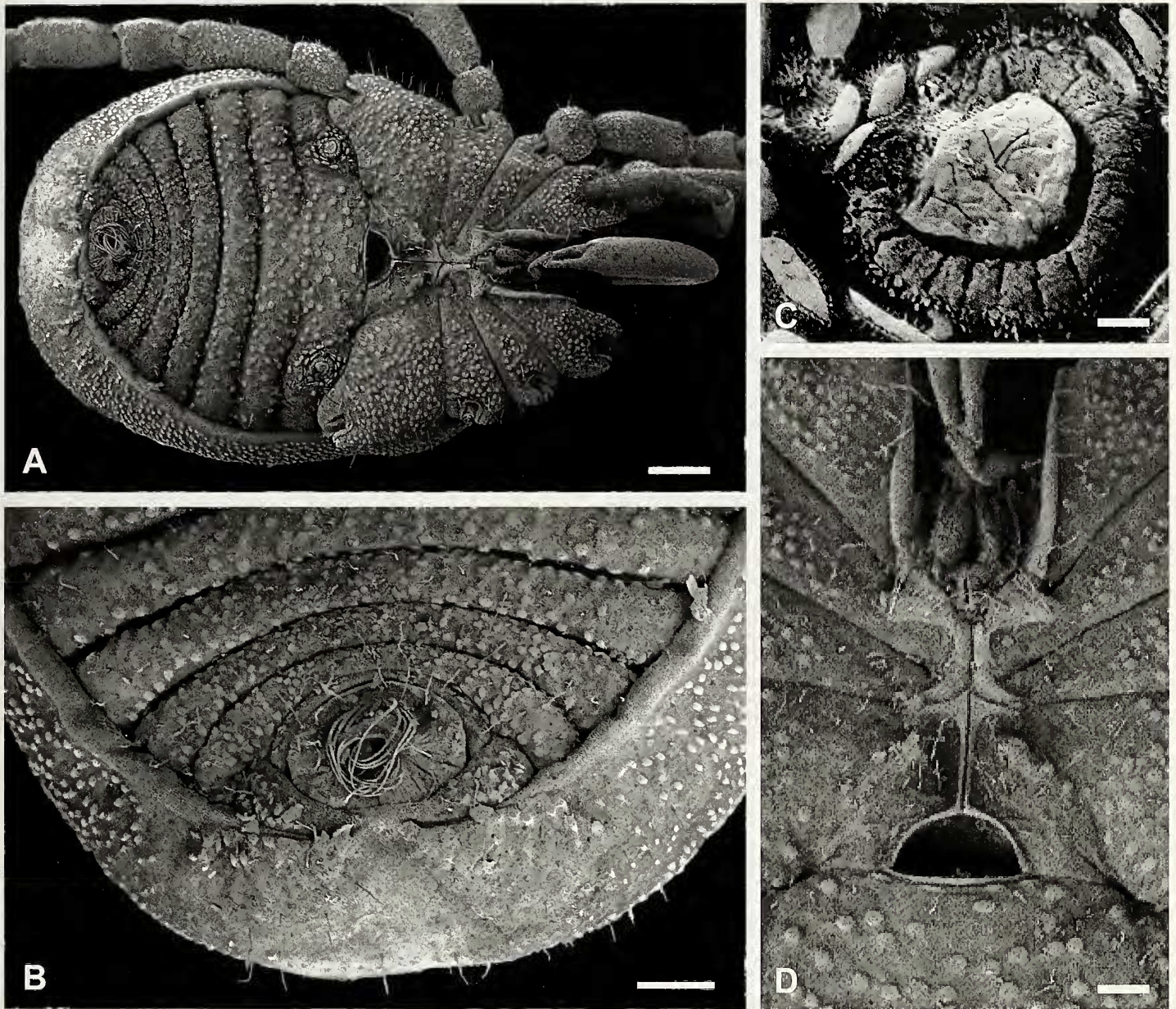


Figure 16.—*Austropurcellia vicina* n. sp., male paratype: A. Ventral view, scale bar = 200 µm; B. Posterior ventral area, scale bar = 100 µm; C. Spiracle, scale bar = 10 µm; D. Gonostome and sternal area, scale bar = 100 µm.

Austropurcellia daviesae (Juberthie 1989)

Rakaia daviesae Juberthie 1989:499.

Type locality.—AUSTRALIA: *Queensland*: Graham Range, 17°17'S, 145°57'E, 9 April 1979, G.B. Monteith, QM Berlesate No. 3 (QM S6441, S6442, S6443).

Additional collections.—AUSTRALIA: *Queensland*: Bellenden Ker National Park, 40 km SSE. of Cairns, 17°15'S, 145°54'E, 100 m, 20–21 January 1992, D. Burckhardt (#18a) (MHNG); 4 km E. of Lake Barine, 17°16'S, 145°41'E, 700 m, 1 July 1971, Taylor and Feehan, ANIC berlesate 352 (ANIC); Lake Barrine, Crater Lakes National Park, Yungaburra, 17°14'44.2"S, 145°38'31.5"E, 19 February 2003, G. Giribet and C. D'Haese (MCZ DNA 100947); Lake Eacham National Park, 17°17'S, 145°37'E (estimated), 25 May 1980, I.D. Naumann and J.C. Cardale, ANIC berlesate 681 (ANIC), mounted for SEM: Macalester stubs 2.3, 2.4; Rose Gums Wilderness Retreat; 17°18'51"S, 145°42'08"E, 15 March 2006, G. Hormiga and L. Lopardo (MCZ DNA101953).

Austropurcellia forsteri (Juberthie 2000)

Neopurcellia forsteri Juberthie 2000:149.

Type locality.—Australia: *Queensland*: 3 km W of Cape Tribulation (site no. 6), 16°04'S, 145°25'E (estimated), January 1983, G.B. Monteith, berlese no. 512 (location of type specimens unknown).

Additional collection.—Australia: *Queensland*: Emmagen Creek, Daintree National Park, 16°3'41.4"S, 145°27'43.8"E, 18 February 2003, G. Giribet and C. D'Haese (MCZ DNA100945).

Austropurcellia scoparia Juberthie 1988

Austropurcellia scoparia Juberthie 1988:133.

Type locality.—AUSTRALIA: *Queensland*: 2 km N of Mount Lewis via Julatten, 1000 m, 16°34'S, 145°17'E (estimated), 9 June 1981, G. Monteith and D. Cook, berlese No. 281 (MNHN).

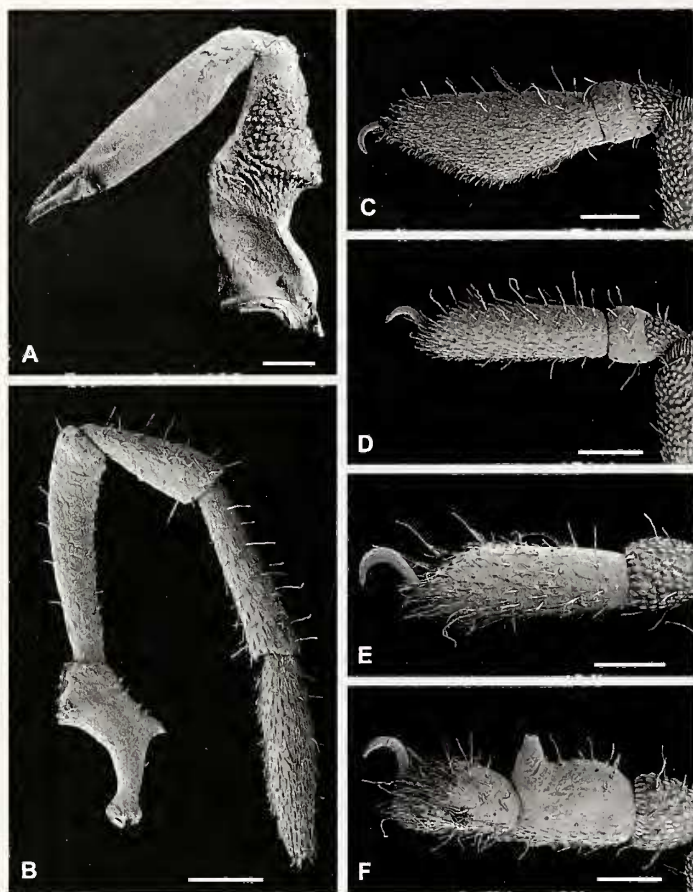


Figure 17.—*Austropurcellia vicina* n. sp., male paratype: A. Chelicera; B. Palp; C. Tarsus I; D. Tarsus II; E. Tarsus III; F. Tarsus IV. Scale bars = 100 μ m.

Additional collections.—AUSTRALIA: *Queensland*: Mount Lewis Road, Julatten, 16°34'S, 145°19'E (estimated), 12 November 1975, A. Wallingford-Huggins (ANIC berlesate 508); Mount Lewis State Forest; 16°35'40.5"S, 145°16'45.5"E, 17 February 2003, G. Giribet and C. D'Haese (MCZ DNA100946).

Austropurcellia woodwardi (Forster 1955)

Rakaia woodwardi Forster 1955:355.

Type locality.—AUSTRALIA: *Queensland*: Clump Point, Great Dividing Range, ex leaf mold, 17°51'S, 146°7'E (estimated), 3 June 1953, T.E. Woodward (QM).

Additional collection.—AUSTRALIA: *Queensland*: Tully Falls, 17°43'S, 145°32'E (estimated), 21 August 1953, W.A. McDougall (QM).

Collections of specimens that cannot be assigned to species (juveniles and females only).—AUSTRALIA: *Queensland*: Eacham National Park; 17°08'S, 145°37'E, 1–7 October 1972, R.W. Taylor (ANIC berlesates 428, 429); Eacham National Park, 760 m, 17°18'S, 145°47'E, 16 February 1973, R.W. Taylor (ANIC berlesate 436); Gap Creek, 5 km SSE of Mt. Finnegan, 15°50'S, 145°20'E, 13–16 May 1971, A. Calder and J. Feehan (ANIC berlesate 736); Lake Barrine, transect on lower slope, Atherton Tablelands, Tullgrens site code F3#2, 17°15'S, 145°38'E (estimated), October–November 2000, H.C. Proctor (MCZ 98676); Malanda Scrub, Atherton Tablelands, Tullgrens site code F2, 17°19'S, 145°30'E (estimated), October–November 2000, H.C. Proctor (MCZ 98674); Mount Edith, N of Tinaroo Falls Dam, 17°06'S, 145°37'E (estimated), 19 May 1980, I.D. Naumann and J.C. Cardale (ANIC berlesate 677); near Mount Haig, 1140 m, 17°06'S, 145°35'E, 30 June 1971, Taylor and Feehan (ANIC berlesate 349); Mount Tiptree, 17°03'S, 145°38'E, 29 June 1971, Taylor and Feehan (ANIC berlesate 345); Tucker (private land) above Johnstone River Gorge, Atherton Tablelands, Tullgrens site code F10, 17°29'S, 145°41'E (estimated), October–November 2000, H.C. Proctor (MCZ 98672).